

THE HAWAIIAN PLANTERS' RECORD

Volume XXI.

NOVEMBER, 1919

Number 5

A monthly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.

Irrigating Plant Cane

It is a common practice among irrigators to irrigate a plant field in the same manner as a ratoon field or a field of big cane. The object seems to be to get as much water in the line as possible, regardless of the age of the cane.

If the contractors can be trained to give the plant fields light irrigations, particularly the first three or four irrigations, germination will be just as good and the water and application cost a great deal less. This can be done by shutting the water off when it is two or three feet from the end of the line, for, with the ordinary grade, there is always sufficient water in the line to cover this distance after the line is closed. The amount of water contained in the ordinary line, when full, is sufficient to wet the land to a depth of six or seven feet, while it is only necessary to moisten the upper six or eight inches of soil until the cane is well up. The water passing to the lower depths is then wasted, particularly in a field that has been steam-plowed, for the plowing loosens the soil and lessens the capillary connection between the surface and the lower depths. As the field settles and becomes more compact, more of the moisture from the lower depths is brought to the surface, but in a freshly-plowed field it is probable that none of the moisture which passes below the surface soil ever gets back to the surface by capillary action.

R. M. A.

Applying Water After Harvesting.

The opinion is held on some irrigated plantations that there is generally sufficient moisture in the soil to bring a ratoon field up. To test this point a field of H 109 at Waipio was divided into two sections and water applied to one of these immediately after harvesting. The original intention was to give the remaining section its first irrigation as soon as a stand was obtained. However, at the end of ten days the portion of the field that had been irrigated was so far ahead of the remaining section that it was necessary to irrigate this in order to preserve a uniform stand for the experiment that had been planned for this field.

This small test showed very conclusively that there is everything to be gained by irrigating as soon after harvesting as possible.

R. M. A.

Fertilization—Plant Food Requirements.

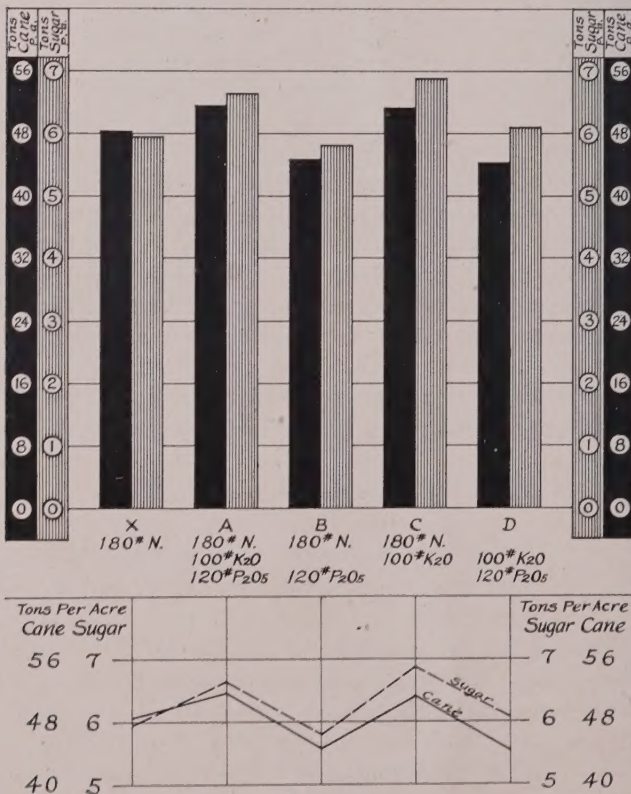
ONOMEA SUGAR CO. EXPERIMENT 9 (1919 CROP).*

SUMMARY.

This experiment is to determine which of the three elements Nitrogen, Phosphoric Acid, and Potash is lacking in the soils of the Hilo district. Comparison is made between (X) Nitrogen alone; (A) Nitrogen, phosphoric acid, and potash; (B) Nitrogen and phosphoric acid; (C) Nitrogen and potash, and (D) Phosphoric acid and potash.

The results show very emphatically that the addition of both potash and nitrogen is of vital necessity for maximum yields, while phosphoric acid, on the other hand, gives no increase in yields.

PLANT FOOD REQUIREMENT.
ONOMEA SUGAR CO. EXP.*9, 1919 CROP
FIELD 3.



* Experiment planned by L. D. Larsen and W. P. Alexander.
" laid out by W. P. Alexander.

[illegible]

Summary Of Results.

Plots	No. of Plots	Treatment	Yields Per Acre			Gain or Loss Due to Adjoining X Plots	
			Cane	Q.R.	Sugar		
A	48	Nitrogen	0	4842	8.14	5.95	0
B	12	K ₂ O	100	5161	7.77	6.64	+391
C	12	P ₂ O ₅	100	4466	7.69	5.81	-421
D	12	100	0	5138	7.47	6.88	+268
E	12	100	100	4435	7.28	6.09	+039

The value of nitrogen is shown by comparing the D and A plots. These plots each received 120 pounds of phosphoric acid and 100 pounds of potash, but the D plots received 45 pounds of nitrogen, while the A plots received 180. The presence of this 45 pounds of nitrogen, which was applied by mistake, makes it impossible to determine the full value of nitrogen, but comparison of the gains of the A and D plots over their respective X plots, shows that 135 pounds of nitrogen increased the yield by 0.39 ton sugar. This conclusion as to the value of nitrogen under Hilo coast conditions is fully corroborated by other experiments conducted in the Hilo district.

The following table shows the treatments and yields:

Plots	No. of Plots	Treatment in Pounds per Acre			Yields in Tons per Acre			Gain or Loss Over Adjoining X Plots	
		Nit.	Phos. Acid	Potash	Cane	Q. R.	Sugar	Cane	Sugar
X	48	180	...	...	48.42	8.14	5.95	0	0
A	12	180	120	100	51.61	7.77	6.64	+ 3.91	+ 0.78
B	12	180	120	...	44.66	7.69	5.81	— 4.21	— 0.19
C	12	180	0	100	51.38	7.47	6.88	+ 2.68	+ 0.90
D	12	45	120	100	44.35	7.28	6.09	— 2.07	+ 0.39

DETAILS OF EXPERIMENT.

Object.

To determine the plant food requirements of sugar cane on the soils of the Hilo district. The comparison is made between—

1. Nitrogen alone.
2. Nitrogen, phosphoric acid, and potash.
3. Nitrogen and phosphoric acid.
4. Nitrogen and potash.
5. Phosphoric acid and potash.

Location.

Field 3, on field path leading to Japanese Cemetery.

Crop.

Yellow Caledonia, second ratoons.

Layout.

No. of plots, 96. Size of plots, 1/15 acre, consisting of 6 lines, each line 5.66'x 85.4'.

Plan.

FERTILIZATION IN POUNDS PER ACRE OF NITROGEN MIXTURE, ACID PHOSPHATE, AND SULFATE OF POTASH.

Plots	No. of Plots	August, 1917			November, 1917			Jan., 1918, N. S.	April 30, 1918, N. S.	Total Pounds per Acre		
		Cl	Acid Phos.	Sulf. Pot.	Cl	Acid Phos.	Sulf. Pot.			N.	P ₂ O ₅	K ₂ O
X	48	257.2	0	0	257.2	0	0	290.3	290.3	180	0	0
A	12	257.2	315.8	104.2	257.2	315.8	104.2	290.3	290.3	180	120	100
B	12	257.2	315.8	0	257.2	315.8	0	290.3	290.3	180	120	0
C	12	257.2	0	104.2	257.2	0	104.2	290.3	290.3	180	0	100
D	12	0	315.8	104.2	0	315.8	104.2	290.3*	0	45	120	100

Cl fertilizer = 17½% nitrogen mixture (½ nitrate of soda; ½ ammonium sulfate.)

* This nitrogen to D plots applied by mistake.

Nitrogen applied first season as 17½% nitrogen mixture, half as nitrate and half as sulfate. Second season as nitrate of soda.

Phosphoric acid applied as acid phosphate (19% P₂O₅).

Potash applied as sulfate (48% K₂O).

Progress.

August 10, 1917—Experiment laid out and staked.

September 5 and 6, 1917—First fertilization as per schedule.

December 10, 1917—Second fertilization as per schedule.

April 11, 1918—Third fertilization as per schedule.

July 18, 1918—Fourth fertilization as per schedule.

August 1-5, 1918—Experiment harvested.

R. S. T.

Seeding Low-Grade Masseccuites.

By W. R. McALLEP.

During the past season the method of graining low-grade masseccuites by drawing powdered sugar into the pan when the molasses is concentrated to the graining point, has been experimented with in several factories. The writer had an opportunity in one instance to compare the results obtained by this method with those obtained by graining in the pan in the ordinary manner.

The following observations were made during the graining of a strike by this method: Fifty-three apparent purity molasses was concentrated till the temperature reached 122° F. under a vacuum of $26\frac{3}{4}$ ". At this point 60 grams of powdered sugar stirred up in a small quantity of syrup was drawn in. The concentrating was continued till a temperature of 128° (vacuum $26\frac{1}{2}$ ") was reached, when the masseccuite was thinned down slightly. No clearly-defined grain could be seen at this time, or for some time afterward, even with a microscope of moderately high power. When the grain did appear it was very even. The final volume of the masseccuite was slightly under 500 cu. ft.

Measurement of the size of the particles of powdered sugar, and a rough calculation, indicated that the amount of seed used was not sufficient to furnish nuclei for all of the crystals in the masseccuite. Further, if the masseccuite had been really "seeded"—that is, nuclei provided for the sugar in the molasses to build on—the grain would have been clearly visible as soon as the seed was distributed throughout the mass. In this method, then, as well as in the ordinary methods of graining, the crystals are not built up around a seed crystal, but are formed from sugar that was in solution. But little difference, then, would be expected in the crystals obtained by the two methods.

Examination of the grain of the masseccuites that were in the crystallizers showed, however, that there were marked differences.

The grain of the seeded masseccuites was very even. There was very little false grain; that is, crystals of from 0.01 to 0.1 mm. in length. The length of the crystals was some three times the width. In the masseccuite, the graining of which was described above, the latter characteristic developed after the masseccuite left the pan. The grain was practically free from conglomerates.

The grain of the unseeded masseccuites was not so even. More false grain was present, and the crystals were of more nearly rectangular section, the length being about twice the width; also some conglomerate grains were present.

All of the low-grade masseccuites boiled during my visit were practically free from false grain when they left the pan. This characteristic developed while in the crystallizers.

Average samples of the sugar from four crystallizers, two seeded and two unseeded, were forwarded to the writer. These masseccuites resulted from cane from the same field, were boiled consecutively, and, with the exception of the method of starting the grain, were handled in as nearly the same manner as pos-

sible. One of them, crystallizer No. 9, was the massecuite, the graining of which has been described.

The following data accompanied the samples:

Cryst No.	Massecuite		Molasses
	Brix	Apparent Purity	Apparent Purity
1 unseeded	97.0	53.6	33.0
3 seeded	96.6	54.5	31.3
9 seeded	96.6	52.9	30.6
14 unseeded	97.6	53.6	32.4

These samples were of the following polarization:

No. 1	79.4
No. 3	84.3
No. 9	83.1
No. 14	79.4

The seeded samples were better dried, and consequently of lighter color than the unseeded, though, indeed, all of the samples were satisfactorily dried.

To determine whether there was a difference in the composition of the crystals themselves, the molasses was removed by the following method: The samples were first shaken in a Coles shaker, with a 75% alcohol solution, saturated with sugar. This separated the crystals and dissolved the greater part of the molasses. The samples were then washed on a 150-mesh screen with more of the same solution, transferred to the 200-mesh screen of a Wagner laboratory sifter, and shaken at 100 r.p.m. for 15 minutes in a bath of sugar-saturated alcohol. The samples were again shaken with fresh solution in the Coles machine, again washed and partly dried in a centrifugal apparatus. The solutions were thoroughly saturated with sugar at the temperature at which they were used.

The above method is not free from objection, as there is some precipitation of constituents of the molasses in the first operation. However, so far as could be detected with a microscope, subsequent operations removed the precipitate formed.

The seeded crystals were much lighter in color than the unseeded after the molasses had been removed.

The analyses* of the air-dried crystals follow:

	Purity	Ash		Sulfates (SO ₃)
		Total	After Filtration	
1 unseeded	95.5	1.80	1.48	0.55
3 seeded	96.4	1.25	1.08	0.43
9 seeded	96.1	1.43	1.20	0.56
14 unseeded	95.4	1.89	1.58	0.57

* Analyses by A. Brodie.

The comparisons made indicate that better results were secured by the seeding method.

In analysis the seeded crystals were of a higher purity and lower ash content. The difference in the sulfate content was not so pronounced. It should be noted, however, that in purity, ash and sulfates, these crystals are inferior to the crystals of commercial sugar,[†] and that if such sugar is used for seeding commercial sugar massecuites the composition of the crystals will be unfavorably affected.

The crystals in both the seeded and unseeded massecuites were of about the same length. The narrow crystals of the seeded massecuites, however, have more surface for a given weight. More favorable crystallizing conditions would be expected in the seeded massecuites on account of this increased surface. That this was indeed the case is indicated by the freedom from false grain and by the analyses that accompanied the samples. These analyses show that lower purity molasses was obtained from the seeded massecuites, even though the latter had a slightly lower density than the unseeded.

The higher polarization, and the appearance of the sugar from the seeded massecuites, indicated that the latter had worked better in the centrifugals. This also would be expected on account of the absence of false grain. These massecuites could undoubtedly have been concentrated to a higher density, and still have worked satisfactorily in the centrifugals. This would have resulted in a molasses of lower purity.

The use of the seeding method has been of decided benefit at this factory. A better grain has been obtained in the low-grade massecuites, than had previously been obtained by graining them in the pan in the ordinary manner. An improvement in the grain makes it possible to separate a molasses of lower water content and consequently higher viscosity from the sugar in the centrifugals, and this in turn permits of the production of a lower purity molasses. A lower purity final molasses resulted at this factory during the latter part of the season after the seeding method had been adopted.

Artificial Distribution of Beneficial Ladybirds in California by the Ton.

By C. E. PEMBERTON.

The artificial distribution of leafhopper parasites on the Island of Hawaii, on a comprehensive scale, has an interesting parallel in this sort of insect control, in work which has been conducted by the California State Commission of Horticulture at Sacramento, California, for the past eight years. Entomologists of this Commission have been yearly collecting and distributing literally millions of

[†] H. S. P. A. Circular No. 24.

aphis-feeding ladybirds of a certain species *Hippodamia convergens*. This insect is already present in most of the localities to which it is being sent, but the theory underlying the work is that a numerical increase of about 30,000 individuals per acre in the fields suffering from aphis attack, will bring immediate and material relief.

Insects of the family *Aphididae*, or so-called plant-lice, are among the most important of insect pests, and the state legislature of California has been willing to finance, already for eight years, the undertaking of the Horticultural Commission in this distribution of ladybirds, even though there has always been considerable doubt as to the actual benefits from such a procedure. They no doubt feel that the yearly losses from aphis, particularly in truck crops, fully warrant the expenditure of money in experiments and demonstrations along this line in spite of uncertainty as to results over a period already covering several years.

This particular project has attracted attention among entomologists and farmers generally throughout the United States, has been described and discussed in many periodicals, scientific papers and newspapers, and has even aroused certain interests in France sufficiently to induce the California people recently to make a shipment of this ladybird to that country.

The methods of collecting this insect in California are absorbingly interesting. In the fall of the year this ladybird flies from the valleys and foothills up into the heads of the canyons of the high Sierras, and here great numbers congregate in masses on low bushes and shrubbery, actually millions clustering together in this way. These particular spots where they assemble are found and marked by men trained and experienced in this work. The exact location of each spot is recorded and filed. Winter comes on and the masses of ladybirds become covered with snow. This does not kill them. Normally they remain here in a sleeping or dormant, hibernating condition until the following spring, when the snow melts and they revive, fly up almost in clouds (according to the report of one observer), and return to the lowlands in search of food. In their return flight they have been followed by one state employe engaged in the work, for ten miles down one of the valleys in a single flight. Before the snow melts, however, the card-indexed clusters of ladybirds are again located, dug up from beneath the snow, cleaned and placed in bags, like so much gold-dust, and taken to a commercial cold storage plant in Sacramento, crated in boxes of 33,000 per lot and held there at a temperature of approximately 40° F. Here they remain for from one to six months, until farmers in various parts of the state report outbreaks of aphis in their crops. They are then removed from storage and immediately shipped to the desired localities and liberated. Great quantities have been handled in this manner. During the spring of 1912, shipments of 44,000,000 were distributed in this manner to the farmers, and in the following year 75,000,000 were sent out. Immense numbers have been yearly handled since.

This ladybird is the most common and most beneficial aphis-feeding species in California. It feeds on many different species of aphis, has been known to take as many as 60 aphids a day, and to lay 1500 eggs in a lifetime. The young, or larvae, have been observed to eat from 250 to 300 aphids during the 18 or 20 days of their development.

In order to determine just what advantages are gained by this wholesale collection and concentration of ladybirds in fields suffering from aphid attack, the State Horticultural Commission, in cooperation with the Federal Bureau of Entomology, has placed a specialist in the Imperial Valley in Southern California, to study the habits of this species and its relation to the aphids, particularly where the gross liberations are being made. It is yet too early for conclusions to be drawn. It is a difficult point to determine.

It is interesting here to note that the results during the past eight years seemed so promising, and the reports from farmers so favorable, that the state has kept up the appropriation for this work for seven years, before finally considering the advisability of placing the whole subject under the expert study of one most able to judge and determine its value as a profitable undertaking.

The possibility of shipping this species to Hawaii in large quantities, to be used in checking sudden local outbreaks of aphid on cane or other plants, has been thought of, and consequently some interest will be directed toward the results of the present studies of this ladybird in California. Attempts have already been made to introduce it into Hawaii. It has not become established so far as known. Other attempts should be made, either by bringing it in, in small numbers by the usual method of colony breeding during transportation, or by an attempt to ship it in hundred-pound lots in cold storage. There are difficulties connected with storage shipments. If the ladybirds can be held at 40° F. or somewhat less, from the time of collection in the snow of California until liberated in Hawaii, results should be good, providing they reach here within eight weeks after collection. Investigations in California show that storage after removal from the natural hibernation spots in the Sierras, for ten weeks or more, causes a large mortality among the ladybirds. We are further not certain that this species will survive in Hawaii. It is not a tropical insect. In view of its importance, however, as an enemy of *Aphididae* in California, further attempts should be made to introduce it into Hawaii. We already have a really remarkable natural control of *Aphididae*, by the ladybirds introduced into the Territory in the past. Few realize or understand what an enormous benefit we constantly get from many species of ladybirds which have been with us in Hawaii now for many years. More species are being introduced, but the best California species should not be overlooked because of the first few failures to establish it here.

Some Temperature Experiments in Clarification.

By HERBERT S. WALKER.

It has always been somewhat of a problem in this factory whether to keep over juices in the settling tanks at the end of the week. The saving in time and in fuel by not boiling off is considerable, but the purity of the juice generally drops from 3 to 6 points in 24 hours. We have tried the usual remedies of overheating, heavy liming, soda and formalin in various proportions, but without much success.

The settling tanks used here hold 1100 cubic feet of juice each and are so well insulated that juice put in at 212° F. drops less than 1° per hour and remains as high as 196° after 24 hours standing. Under such conditions it is difficult to conceive of any heat-resisting organisms being lively enough to start a fermentation, although the kept-over juices always dropped in purity, became slightly acid to litmus, and developed a "sour" odor.

The first clue to the real cause of this deterioration came from a test which was made to find out just how much value formalin was in preserving juices.

The raw juice in this experiment, after liming to slight litmus alkalinity as usual, was made just alkaline to phenolphthalein with carbonate of soda and heated to 215° F. One settling tank of this juice was treated with formalin solution in the proportion of about 1 to 4000; another was allowed to stand without further treatment. Juices were sampled one-half hour and twenty-four hours after tanks had been filled.

	Initial Purity	Final Purity	Loss
With formalin	86.8	82.6	4.2
Without formalin	87.5	84.5	3.0

As the juice containing formalin deteriorated worse than the other, it seemed that the loss was probably due, not to some heat-resisting organism, but to the heat itself.

The next time juice had to be kept over we tried filling one tank at a lower temperature and got very encouraging results:

Temperature		Purity		Loss
Initial	Final	Initial	Final	
212° F.	196° F.	86.0	81.5	4.5
188° F.	175° F.	86.1	85.4	0.6

Time of standing—25 hours.

The juice in both tanks had, for precaution, been made just alkaline to phenolphthalein with sodium carbonate. This was unnecessary, as was shown the following week, when only one tank was kept over. This was limed as usual, no soda added, heated only to 180° F. and kept for 31 hours. Samples were taken through a small test pipe near the top of the tank. No sample was taken until the tank had stood for 6 hours, so they all represent clear juice and there can be no question of the uniformity of tank contents.

Time Standing	Temperature	Purity
6 hours.....	178° F.	86.1
18 ".....	175° F.	86.3
30 ".....	170° F.	86.8
31 ".....	170° F.	86.5

The final clarified juice was exceptionally bright, and still alkaline to litmus. The *gain* in apparent purity may have been due to destruction of fructose, though experimental error might easily account for most of it, since the samples were run by the laboratory boys in the course of their routine work, with no attempt at more than ordinary accuracy.

Subsequently an endeavor was made to get data which could be plotted in a curve to show the comparative rate of decomposition at different temperatures. The same tank was filled on separate days at temperatures ranging from 212° F. to 186° F. and kept as long as possible without risking a serious loss, samples being analyzed every two hours. The results obtained, while interesting as showing the markedly greater total decomposition occurring in the hotter juices, were too irregular to allow of any conclusion as to the rate of loss from hour to hour, since the experimental error of a single determination may amount to nearly 1%, or more than the actual loss in several hours.

Following is a summary of five tests made:

Initial temperature	212° F.	212° F.	200° F.	190° F.	186° F.		
Final temperature	200° F.	200° F.	190° F.	178° F.	168° F.		
Hours standing	20	21½	21½	38	35	43	49
Hours before acid to litmus....	6	5½	15½	12		35	
Initial purity	90.4	86.1	86.7	86.7		85.1	
Final purity	86.1	80.2	84.0	86.0	84.5	84.5	83.8
Loss	4.3	5.9	2.7	0.7	0.6	0.6	1.3
Loss per hour.....	0.215	0.275	0.125	0.018	0.017	0.014	0.026
Loss % total polarization....	4.76	6.85	3.11	0.81	0.71	0.71	1.52
Loss % total pol. per hour....	0.238	0.319	0.144	0.021	0.020	0.017	0.031

The practical loss is, of course, considerably greater than that due to the drop in polarization, on account of diminished yields at lower purities. Calculated on 100 tons of juice of 15 Brix and 86 purity, dropping to 82 purity in 24 hours standing, the loss in 96° sugar recovered would be as follows:

100 tons juice at 15 Brix and 86 purity = 12.9 tons polarization. Recoverable at 33 apparent purity molasses, by *s j m* formula = 93.4% = 12.05 tons polarization.

100 tons juice at 15 Brix and 82 purity = 12.3 tons pol. Recoverable at 33 apparent purity molasses, 90.57% = 11.14 tons pol.

Loss of recoverable polarization = 0.91 tons pol.

Loss per cent total polarization = 7.55%.

Loss as 96 sugar, per cent total polarization = 7.87%.

For every ton of sucrose (polarization) in mixed juice kept 24 hours in the settling tanks there is lost 0.0787 ton 96° sugar, worth, at \$120 net per ton, \$9.44.

In this factory it has been the practice to keep two tanks of juice over—about 70 tons of juice or 9 tons polarization—on which the loss would amount to \$85 per week or nearly \$3000 for the season. This is a comparatively small loss, but one worth stopping, as it can be eliminated by reducing the temperature of the juice to be kept over to 180° F.

In the case of factories which grind only during the day, letting juice stand in the settling tanks over night, the amount of sucrose decomposed in a season must be considerably greater, except where insulation is so deficient as to allow the settling tanks to cool down quickly and substitute heat loss for sucrose loss.

Finally, it is quite possible that this loss by decomposition may be still more serious, in that it may affect, not just the comparatively small amount of juice kept over at week ends, but all the juice worked up in the factory. If, as is conceivable, a drop in purity from 86 to 82 in 24 hours is uniform throughout the

period, then per hour, per ton of sucrose in juice, there are lost $\frac{0.0787}{24} = 0.00328$

tons of 96° sugar. In this factory there were handled last year some 32,000 tons polarization in the juice, which was kept at around 210° F. about two hours. The calculated loss would be 210 tons of sugar, worth over \$25,000.

As stated before, this last proposition is very difficult to prove with ordinary mill laboratory facilities owing to the very slow rate of decomposition causing less change in one hour than could be produced by analytical errors. The problem could only be solved by a large number of very careful tests. The probabilities are, however, that the drop in purity during the first two hours is not exactly one-twelfth of that in 24 hours. It may well be so that comparatively little sucrose is lost until a certain amount of acidity, due to decomposition of reducing sugars, has developed; on the other hand, the loss may be greater during the first few hours standing on account of the higher temperature at that time. In any event the remedy is simple and inexpensive, and consists in keeping the temperature of clarification down to as near 180° F. as is consistent with good settling within the time allowed by the available settling tank capacity. To avoid overtaxing the evaporators it would be necessary in most factories to put in additional heaters for reheating the clarified juice just before it enters the evaporator.

SUMMARY.

Limed and heated cane juices kept in well-insulated settling tanks dropped in temperature from 212° F. to about 196° F., and in purity from 3 to 6 points on standing for 24 hours. Experiments showed that the loss in purity can be prevented by lowering the initial temperature to 180° F. Formalin was of no value. If the drop in purity is proportionately as great during the first two hours as that observed in 24 hours, the loss involved is a fairly serious one when figured over a year's crop. Clarification should be carried on at as low a temperature as practicable and the clarified juice reheated.

Seed from Plant, Ratoon, and Cut-back Cane.

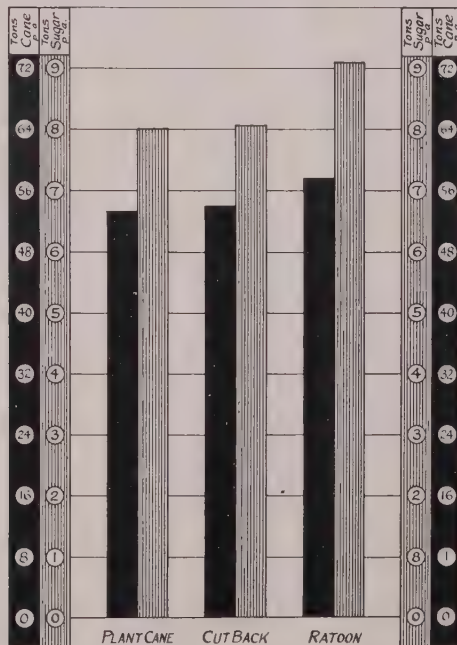
WAILUKU SUGAR CO. EXPERIMENT 6 (1919 CROP).*

This test compares Lahaina body seed taken from plant, ratoon, and cut-back cane.

Seed from these three sources was planted in alternate plots of 1/20 acre, each consisting of 12 rows. At harvest the two middle rows of each plot were weighed and juice samples taken from each plot.

The results are in favor of using ratoon cane for seed. Cut-back and plant cane give practically identical yields of 8 tons sugar per acre, while ratoon cane gives 9 tons of sugar, a gain of one ton of sugar. While these differences in yield are unexpectedly high to be due solely to a difference in the character of seed-cane, yet the results, as they stand, are interesting, and deserve to be published, if for no other reason than to bring about a more thorough study of this subject. The tabulated results follow:

SEED FROM PLANT, RATOON & CUTBACK CANE.
WAILUKU SUGAR CO. EXP. #6, 1919 CROP



* Experiment planned by H. B. Penhallow and J. T. Moir, Jr.
" laid out by J. T. Moir, Jr.

Seed from—	No. Plots	Tons per Acre		
		Cane	Q. R.	Sugar
Plant	5	53.03	6.62	8.01
Cut back	5	53.94	6.69	8.06
Ratoons	8	57.56	6.34	9.08

DETAILS OF EXPERIMENT.

Object.

To compare the value of plant, ratoon, and cut-back cane for use as seed.

Location.

Field 45.

Crop.

Lahaina, plant.

Layout.

18 plots, each $1/20$ acre, consisting of 12 rows, each row 5'x 36.3'. (Note:—At time of harvest only the two middle rows of each plot were scaled and samples taken for juice analysis.)

Plan.

Plot	No. Plots	Source of Seed
P	5	Plant
CB	5	Cut back
R	8	Ratoons

Fertilization uniform to all plots.

Progress.

July 14, 1917—Seed planted.

August 18-20, 1917—Fertilized, 450 lbs. B 5 per acre.

December 7, 1917—Fertilized, 450 lbs. B 5 per acre.

March 26, 1918—Fertilized, 200 lbs. N. S. per acre.

June 25, 1918—Fertilized, 200 lbs. N. S. per acre.

February 7, 1919—Experiment harvested by Y. Kutsunai.

R. S. T.

The Ash of Cane Juice.

ITS RELATION TO VARIETY OF CANE, PURITY OF CANE, AND TO NITROGEN AS A FERTILIZER.

By R. C. PITCAIRN.

During April, May and June of the present year I made a number of ash determinations at Wailuku, Maui, T. H., primarily with the object of determining if I could find any relation between the amount and character of the original ash and its effect on our low final molasses.

Owing to the late start, I soon found that I could only make a beginning this season, as my final results would have to be worked out by a system of elimination. During the course of these investigations a number of interesting relationships appeared that I am going to call attention to in the following notes.

All samples were taken from the crusher juice (continuous samples) except in two of the mills at Hawaii, where the crusher and first-mill juices were combined. All samples were decanted and run in duplicate, 20 grams of the sample taken, evaporated over a hot water bath, treated with 1 cc. concentrated sulphuric acid, heated gently at first, and finished to constant weight at a dull red heat in a muffle furnace.

I subtracted 10% of the weight of the sulfated ash to get the carbonated ash, realizing at the time that the 10% is only an approximate estimate at best. Following are a list of the different varieties run and average results:

Variety	No. of Samples	Brix	Pol.	Purity	Carbonate Ash	Saline Coef.	T.C.T.S.
H 109	10	19.58	17.52	89.48	0.2923	59.9	7.67
Striped Mexican	4	18.31	16.38	89.46	0.3465	47.3	7.99
Lahaina	22	21.97	19.51	88.80	0.4466	43.7	7.31
D 1135	14	18.87	16.27	86.22	0.5776	28.2	8.52
Caledonia (Maui)	4	16.98	14.07	82.86	0.6224	22.6	9.69
Caledonia (Hawaii) ..	8	18.40	16.25	88.30	0.5511	29.5	8.11

First. It will be noticed that each variety of cane has its distinctive ash content, thus proving, I believe, the contention of many sugar-boilers that one cane handles more easily than another from a boiling-house standpoint, as the influence of the quantity of ash contained in a juice or syrup on the quantity of molasses produced is a well-known fact, and has been gone into and proved by H. Pellet, L. Pitot and others. The above relationship seems especially valuable, as it is a matter of vital importance to a mill or boiling-house. For example, if a cane is deteriorating, in the selection of a cane to replace it, this factor should be taken into consideration. If it is not, and, say, D 1135 is substituted for Lahaina, the entire capacity arrangement of the boiling-house is disjointed.

Second. It will be noticed there is a fairly accurate ash to purity relation-

ship established. This was borne out through all the work, but was not always positive, as, for example, in the H 109 samples.

H 109.

Brix.	Pol.	Purity	Carbonate Ash	Saline Coef.
14.95	12.88	86.20	0.3594	35.8
20.50	18.26	89.10	0.3534	51.7
22.60	20.33	90.00	0.2507	81.1
19.58	17.73	90.60	0.2700	65.7
20.26	18.40	90.80	0.2281	80.7

This is rather interesting, especially when it is remembered that as yet there has been no ash to purity relationship established in the final products. There has been seemingly a relationship spoken of by H. Zitkowski of the American Beet Sugar Company, and others, in the relationship between lime salts and the final purities in both cane and beet.

Third. Following are the average results of twelve samples run on an experimental field at Wailuku to see if any relationship could be established between the amount of nitrogen applied and the ash content:

Field	Brix	Pol.	Purity	T. C. T. S.	Lbs. Nit. Applied	Ash Carb.	Saline Coef.
1 A	23.41	20.58	87.91	6.34	77	0.42457	48.5
1 B	22.99	20.03	87.12	6.65	154	0.42939	46.6
1 C	22.86	19.58	85.65	6.86	232	0.41850	46.8
1 D	22.64	19.61	86.62	6.80	309	0.44887	43.7

It will be seen that the ash content is practically the same in all cases, and the nitrogen has only a very little effect on the ash content. A slight relationship exists in the saline coefficient, and, as it is practically constant, it would appear that the smaller amount of nitrogen would be preferable from a sugar-making standpoint.

Fourth. A rather interesting fact appears in connection with the samples from the Island of Hawaii. The carbonate ash from the Caledonia cane appears to about equal the ash of D 1135 on Maui, and to be even higher than the average ash on Maui, while the ash of the molasses from Hawaii invariably shows from 3% to 7% lower than on Maui, making it appear that this difference might be due to the relationship between the soluble and insoluble ash, and the mechanical chemical action that takes place during the process.

Fertilizer—Number of Applications.

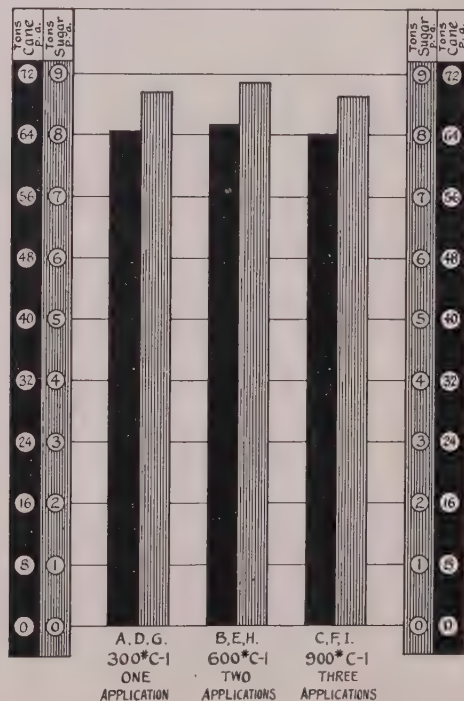
HILO SUGAR CO. EXPERIMENT 5 (1919 CROP.)*

SUMMARY.

This experiment compares applying 52.5, 105, and 157.5 pounds of nitrogen in one, two, and three doses during the second season. The first season fertilization was uniform to all plots and consisted of 148 pounds of nitrogen and 80 pounds of phosphoric acid.

The results are in favor of one dose of fertilizer rather than more. The difference between one and two doses is in favor of two, but the difference is so small that it may be considered well within the limits of experimental error. This confirms the results obtained two years ago (Record, Vol. XVII, page 97).

SECOND SEASON FERTILIZATION—NUMBER OF APPLICATIONS.
Hilo Sugar Co. Exp.*5, 1919 crop



* Experiment planned in 1916 by L. D. Larsen.
“ laid out in 1916 by L. D. Larsen and J. S. B. Pratt, Jr.

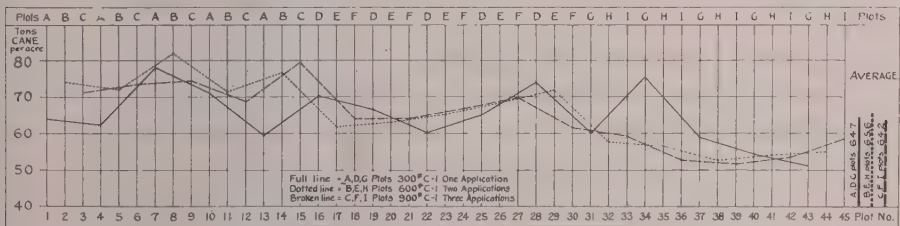
The average results by number of applications are as follows:

No. of Applications	Plots	No. of Plots	Yields per Acre		
			Cane	Q. R.	Sugar
1	A, D, G	15	64.7	7.41	8.73
2	B, E, H	15	65.6	7.39	8.88
3	C, F, I	15	64.2	7.41	8.66

The following table shows the average yields by amounts as well as by number of applications:

Plots	Fertilization—Pounds Nitrogen per Acre			No. of Doses	Yields in Tons per Acre		
	Apr. 18, 1918	May 24, 1918	July 11, 1918		Cane	Q. R.	Sugar
A	52.5	...	...	1	66.6	7.74	8.60
B	26.25	26.25	...	2	75.3	7.47	10.08
C	17.3	17.3	17.3	3	71.9	7.17	10.03
D	105	...	...	1	67.4	7.23	9.32
E	52.5	52.5	...	2	66.0	7.42	8.90
F	35	35	35	3	65.4	7.34	8.91
G	157	...	...	1	60.2	7.29	8.26
H	78.5	78.5	...	2	55.4	7.22	7.67
I	52.3	52.3	52.3	3	55.2	7.82	7.06

AMOUNT FERTILIZER TO APPLY.
HILD SUGAR CO. EXP. *5, 1919 CROP



DETAILS OF EXPERIMENT.

Object.

To compare different numbers of applications of varying amounts of fertilizer.

Location.

Field 6, plots 1 to 45, inclusive.

Crop.

Yellow Caledonia, second ratoons.

Layout.

No. of plots, 45.

Size of plots, 1/10 acre, consisting of 6 lines, 5.16' by 140.7'. (*Note*:—At harvest only the four middle lines of each plot were scaled.)

AMOUNT FERTILIZER TO APPLY.

Hilo Sugar Co. Exp. 5, 1919 Crop

Field 6.

Summary Of Results.

Plots	No. Of Plots	Second Season Treatment	Yields Per Acre		
			Cane	Gr. Sugar	Sugar
A	5	30.0 Pounds C-I	66.6	7.74	8.66
B	5	30.0 Pounds C-I	75.3	7.77	10.09
C	5	30.0 Pounds C-I	71.9	7.17	10.09
D	5	60.0 Pounds C-I	67.4	7.23	9.32
E	5	60.0 Pounds C-I	66.0	7.42	8.90
F	5	60.0 Pounds C-I	65.4	7.34	8.91
G	5	90.0 Pounds C-I	60.2	7.29	8.26
H	5	90.0 Pounds C-I	55.4	7.22	7.67
I	5	90.0 Pounds C-I	55.2	7.82	7.06

46A	1 A	64.05
	2 B	74.10
	3 C	71.18
	4 A	62.42
	5 B	72.00
	6 C	73.47
	7 A	78.00
	8 B	82.08
	9 C	74.18
	10 A	71.07
	11 B	71.34
	12 C	68.67
	13 A	59.63
	14 B	76.92
	15 C	79.71
	16 D	70.14
	17 E	61.82
	18 F	64.11
	19 D	66.75
	20 E	63.08
	21 F	64.11
	22 D	60.38
	23 E	65.24
	24 F	66.96
	25 D	65.25
	26 E	68.58
	27 F	69.98
	28 D	74.21
	29 E	72.08
	30 F	61.77
	31 G	60.14
	32 H	57.87
	33 I	59.34
	34 G	75.83
	35 H	56.87
	36 I	52.89
	37 G	59.06
	38 H	52.97
	39 I	51.71
	40 G	54.71
	41 H	54.24
	42 I	53.67
	43 G	51.08
	44 H	55.07
	45 I	58.65

90' 140.7' 120'

(Exp. 4.)

1392'

Field Road

(Exp. 7.)

Plan.

SECOND SEASON FERTILIZATION.

No. of Applications	Plots	No. of Plots	Pounds Fertilizer per Acre			Total Lbs.
			Mar., 1918	May, 1918	July, 1918	
1	A	5	300	...	...	300
	D	5	600	...	...	600
	G	5	900	...	...	900
2	B	5	150	150	...	300
	E	5	300	300	...	600
	H	5	450	450	...	900
3	C	5	100	100	100	300
	F	5	200	200	200	600
	I	5	300	300	300	900

First season fertilization—uniform to all plots—consisted of 1000 pounds B-5 and 250 pounds nitrate of soda.

B-5=11% N. (5% nit. soda, 5% sulf. amm., 1% organic).

8% P_2O_5 (5% bone meal, 3% super.).

N. S.=15.5% N.

Second season fertilization was with C1 = $17\frac{1}{2}\%$ nitrogen: half nitrate and half sulfate.

Progress.

May 26-June 5, 1917—Previous crop harvested.

July 28, 1917—Experiment staked.

August 11, 1917—Restaked rear line of plots.

September 17, 1917—Fertilized, nitrate of soda, 250 lbs. per acre.

December 12, 1918—Fertilized, B-5, 375 lbs. per acre.

January 22, 1918—Fertilized, B-5, 625 lbs. per acre.

April 17 and 18, 1918—Fertilized, C1, according to schedule.

May 24, 1918—Fertilized, C1, according to schedule.

July 11, 1918—Fertilized, C1, according to schedule.

July 12-24, 1919—Experiment harvested.

R. S. T.

Island Feed for Plantation Livestock.

The feeding of plantation livestock with Island-grown produce has become a matter of vital interest to every plantation with the increasing prices of imported foodstuff.

In the "Question Box" of "The Advertiser" of September 5, 1919, Mr. F. G. Krauss of the Haiku Experiment Station, on Maui, replies to an inquiry from Mr. H. B. Penhallow of Wailuku Sugar Company, giving data for the feeding of

167 head working mules, 43 head saddle horses, and 50 head dairy cattle, a total of 260 head of livestock.

"This will vary from year to year to some extent," states Mr. Penhallow in his letter of inquiry, "so it will be well to allow some leeway—but the above will serve as a base to figure on. Any surplus feed can easily be disposed of I am sure, but would not want to have too much."

The reply of Mr. Krauss reads as follows:

"I would suggest the following cropping system for your needs, based on the conditions as I saw them recently:

DEVELOP ALFALFA.

"For the dairy herd of 50 cows, I would advise developing your alfalfa crop to the extent that all roughage could be supplied from this source. The average 1000-pound cow will consume approximately 40 pounds green alfalfa daily, unless she receives good pasture. Thus your dairy herd would eventually consume about 1 ton of green alfalfa daily. I have assumed that your taro lands could be made to produce about 30 tons per acre per annum. (They may do much better than that; the estimate I have made is, I think, conservative.) You would therefore require 12 to 13 acres of alfalfa for the dairy herd roughage feed alone. I should advise increasing the alfalfa-acreage to 20 acres. The surplus crop would then be fed either green or cured as hay to saddle horses and work mules. Or it could be ground into meal as a base for your grain ration to any or all three classes of stock. As a hay or meal product this surplus crop, over what is needed for your dairy herd as green roughage, should amount to approximately 50 tons, i. e., 50 tons of hay or meal per annum. For the strictly grain portion of your ration, for both cows and horses as well as mules, corn, if you can grow it economically, should be your main standby, but up to 35 per cent of your grain ration, or rather concentrates, could well be molasses. The pigeon-pea crop, which we recommend so highly, would form part of the roughage, substituting alfalfa meal and partly the strictly grain ration.

ACREAGE NECESSARY.

"Taking the 260 head of live stock to be fed as a unit, we would say that there should be provided 12 pounds concentrates per head per day, or a total of 3120 pounds daily. If made up of equal parts corn, pigeon peas and molasses—a very fine general ration for all the stock—you would probably need to grow the following acreage annually of the several crops:

"Estimating corn to yield 1 to 1½ tons shelled grain per acre, about 150 acres would need to be planted in this crop, and about an equal amount in pigeon peas. The corn, of course, would have to be planted annually, while the pigeon peas once every three or four years. In addition to the above grain there would have to be supplied about 190 tons of molasses annually. The above would then make up the total 569 tons of concentrated feed required to allow the 12 pounds per head, per day, to 260 animals. The 'margin of safety' is taken care of by the corn stover resulting from the corn crop. This should amount to a tonnage at least equal to the corn grain, or may even be double that amount. Likewise with the pigeon-pea crops. We assume that you would still feed largely of cane tops, and this would be further insurance.

NEEDS TABULATED.

"To recapitulate, then, the following crops and acreage would be necessary to care for your needs:

ALFALFA—To supply 50 head dairy cows with 40 pounds per head per day; estimated yields 30 tons per acre per annum.....	12½ acres
ALFALFA—To supply a reasonable surplus for curing for hay, and to grind up for meal to be mixed with concentrate rations.....	7½ “
CORN—For the production of 190 tons grain to make up part of grain ration for entire stock, numbering 260 head; stover from above also to supply surplus roughage	150 “
PIGEON PEAS—For use as corn, see above.....	150 “
PASTURAGE—Furnished by corn land during fallow season; also pigeon-pea field every third or fourth year; likewise Manienie pastures.	
Total area in crops.....	320 “

“If algaroba beans are in plentiful supply they can be substituted pound for pound for corn, and this may on occasion be far cheaper than you can grow corn. Other crops than the above will suggest themselves from time to time. Peanuts, I think, you could grow successfully and would greatly improve the grain ration. Likewise could cowpeas be grown to advantage. Trusting that the foregoing may be suggestive, * * *”

[W. P. A.]

Rice Straw Mulches for Sugar Cane.*

Some interesting trials with mulches of straw were made. Owing to the increasing scarcity of sulfate of ammonia, it is necessary for planters to seek for other sources of nitrogen, the yield of cane being pre-eminently due to, and largely in accordance with, the quantities of this important constituent in a readily available form. Rice straw as a mulch has proved very successful in the Botanic Gardens, British Guiana, for fruit trees, economic plants, and palms, and the following is a summary of the results obtained with this material, using nitrogen, and potash in addition:

WEIGHT IN TONS PER ACRE CANE.

	Without Rice Straw				With Rice Straw			
	D 625	D 118	D 145	Mean	D 625	D 118	D 145	Mean
No Nitrogen	31.1	22.8	19.5	24.4	28.3	28.5	21.0	25.9
Potash only	28.1	25.3	19.2	24.2	32.8	30.1	23.5	28.8
Nitrogen only (200 lbs. S. A.)	35.7	29.1	19.2	28.0	32.8	28.4	30.2	30.5
Potash and Nitrogen (200 lbs. S. A.)	31.1	32.5	25.9	29.8	43.0	34.0	25.9	34.3
Potash and Nitrogen (300, 400, 500 lbs. S. A.)....	47.7	34.4	32.0	38.0	48.0	36.7	34.5	39.7

Hence it appears from this comparison that the gain in the tons of cane per

* J. B. Harrison and Robert Ward, in Journal of the Board of Agriculture of British Guiana, 1918, II, No. 4, pp. 135-143.

acre may have been largely due to the nitrogen supplied by the rice straw. It is evident that it is worth the time of the planter to make large scale experiments with any rice straw produced on his estate, bearing in mind that the full advantage of the treatment will not become apparent until repeated over several crops. Other trials indicate that the supply of immediately available potash in the soil has become somewhat depleted so that the nitrogenous dressings as well as the readily available nitrogen of the soil cannot exert full effect unless aided by application of potash salts.

[W. P. A.]

Determination of the True Dry Substance Content of Sugar Products Using Solution Factors.*

By J. P. OGILVIE and J. H. LINDFIELD.

As Dr. Prinsen Geerligs remarks in his standard work on chemical control in the cane sugar factory,¹ it would be a very great advantage if it were possible directly to ascertain the *true* dry substance content of the juices, syrups and other products "instead of calculating this value from the readings of refractometers with the aid of tables, which have been constructed, not for the dry substance of these juices, syrups and other products, but only for one of their constituents, viz., the sucrose."

At the present time the so-called "true" dry substance is determined by the desiccation method, which, though it may be reliable in the case of the purer products, is generally recognized still to leave something to be desired in that of molasses. Such impure products are susceptible to decomposition during desiccation under ordinary conditions of working, and this may be due either to destruction of the levulose, or to the reaction that may take place between reducing sugars and amino-acids, carbon dioxide being evolved. Probably it is due to both causes.²

It has occurred to the authors that probably more reliable results would be obtained by the method depending upon the use of a solution factor, as was first proposed in 1876 by Cornelius O'Sullivan,³ a method that is now in general use in this country for the determination of the water content of commercial invert sugars, table syrups, and similar products.

It will be remembered that this investigator pointed out that a solution of 10 grms. of maltose dissolved in 100 cc. of water at 15.5° C. had a specific gravity of 1038.5 (that of water being taken as 1000). Assuming the concentration to be proportional to the specific gravity, a 1 per cent solution would have a specific gravity of 1003.85, and solutions containing 1 to 10 grms. of this carbohydrate would have intermediate values. Consequently, if each per cent of maltose raised the specific gravity of a solution by 3.85, the amount present in solution could

* The International Sugar Journal, August, 1919, p. 398.

¹ "Chemical Control in Cane Sugar Factories," p. 26.

² I. S. J., 1914, pp. 184 and 230.

³ Journal of the Chemical Society, 1876, Vol. II, p. 129.

easily be determined. It would only be necessary to subtract 1000 from the specific gravity ascertained, and to divide the figure by 3.85. Thus, if a solution of maltose were found to have a specific gravity of 1055, it would contain $1055 - 1000 / 3.85 = 14.285$ grms. per 100 cc. of that substance in solution.

Later, Brown and Heron⁴ found 3.9314 to be the correct divisor for maltose; but, since it had been noticed that in the case of solutions of the different sugars the specific gravity of the solution is not proportional to the amount of substance in solution, 3.86 was proposed⁵ as the solution factor for all cases. This value was given as correct for a 10 per cent solution of sucrose, which has a specific gravity of 1038.6 at 15.5° C.

Some years afterwards, Brown, Morris and Millar⁶ stated that, provided the solution weight of a substance for each degree of concentration is accurately known, the determination of the solids in solution from the density is capable of at least as great an accuracy as a determination effected in the usual manner by drying, unless in this second method special precautions (difficult, if not practically impossible, in the ordinary routine of analytical work), are taken. They made fresh determinations of the solution factors for a number of sugars and starch transformation products, expressing the results obtained in a series of curves indicating the particular divisor to be employed at a series of different concentrations. It is apparent from these curves that the divisor varies with the concentration; so that, in the case of sucrose, whilst it is exactly 3.86 at 1055, it rises to 3.868 at 1020. After careful consideration, it was agreed by these authors also that the factor 3.86 might be adopted as the one generally applicable in commercial analysis when following this method of determining the dry substance by this solution factor method. More recently Ling, Eynon and Lane,⁷ using sugars the purity of which was beyond question, examined the values given by Brown, Morris and Millar, and were able to confirm their accuracy.

As stated, this method (using the factor 3.86) is the one generally adopted at the present time in this country for the determination of the dry substance content (or conversely of the water) in invert sugars, being regarded as considerably more reliable and also more rapid than the ordinary desiccation process. It is necessary, of course, to apply a correction for the ash present, and the method of calculation employed in the case of a brewers' invert sugar is here given.

A 20 per cent solution of the sample was prepared, and its specific gravity determined by means of a Sprengel tube or bottle, the value 1064.9 being found. Hence, the total solids, including that due to the ash present, are: $1064.9 - 1000 / 3.86 = 16.81$ or 84.05 per cent. An ash determination gave 1.62 per cent. It has been shown that the solution factor for the ash present in these products may be taken as 8.0. Therefore, $1.62 \times 8.0 / 3.86 = 3.35$ per cent is the proportion of solids due to the ash, so that the correction is as follows:

⁴ Journal of the Chemical Society, 1879, p. 618.

⁵ Ibid., 1879, p. 602.

⁶ Ibid., 1897, pp. 71 and 73.

⁷ Seventh International Congress of Applied Chemistry, London, 1909; Journal of the Society of Chemical Industry, 1909, pp. 28 and 730.

Total solids, per cent.....	84.05
Solids due to the ash, per cent.....	3.35
<hr/>	
Solids due to sugars and other organic matter, per cent.....	80.70
Ash, per cent	1.62
<hr/>	
Total true solids, per cent.....	82.32
Water, per cent (by difference).....	17.68
<hr/>	
	100.00

It is now suggested that the principle of this method might with advantage be tested by sugar chemists with a view to determining its suitability for the determination of the true dry substance in factory control. The authors had intended to ascertain the solution factors obtaining at temperatures such as prevail in tropical laboratories in the case of sucrose, dextrose, and levulose, and also in that of the ash and organic non-sugars of cane sugar factory products, in order to establish average solution factors for juices, syrups, massecuites, molasses, etc.; but lack of time has made this impossible. They also had in view a series of determinations comparing the results given in the case of different products by the proposed method with those obtained by others, namely, those involving (1) desiccation; (2) the use of the refractometer; and (3) the use of the hydrometer; and generally to examine the possibility of the method in respect of accuracy and rapidity. It is hoped that now others may take up this investigation.

Another proposal, which might prove of practical value in obviating a large proportion of the work at present necessary in the routine determination of the "true" dry substance, may be made.

In the method under discussion the factor is ascertained by the use of solutions of pure sugars, and of solutions of non-sugars; but a step beyond would be to establish a factor by the use of a particular class of sugar factory product, the true dry substance content of which is known, and to apply this factor to the rapid determination of the true dry substance in individual samples of that product.

This suggestion would be carried into operation, firstly, by ascertaining the dry substance of the particular product by the method that at present is believed to give results most closely approximating to the truth, namely, that involving desiccation, using as representative a sample as possible; and secondly, by determining the specific gravity at the prevailing laboratory temperature of a solution of the product containing exactly 10 or 20 grms. of actual dry substance in solution. This value would give the solution factor of the particular class of product at the temperature and concentration chosen; and factors would in this manner be established in turn for juices, syrups, massecuites, sugars, and molasses. These probably would not be found to vary very much one from another, excepting in the case of molasses (in which the mineral matter is most concentrated).

Such a procedure, it is believed, could be followed for the rapid routine determination of the "true" dry substance in all sugar factory products with satisfactory results. In place of determining the "true" dry substance directly by desiccation in every sample, it is more than probable that it would be found that one determination by desiccation in every ten samples at most would suffice to

ensure the constancy of the solution factor. In the case of any particular class of product, as molasses, it is unlikely that the mutual proportions of sucrose, reducing sugars, organic non-sugars, and ash controlling the factor would vary throughout the season to any extent sufficient appreciably to disturb it. The constituent most liable to effect an alteration in the factor would of course be the mineral matter; and therefore an ash determination at intervals might be carried out as a precaution.

Regarding the rapidity of the proposed method, it is certain that it would demand considerably less time than a desiccation determination, and it is likely that in routine work it would prove almost as expeditious as a Brix determination using the hydrometer. Once the factor had been established, it would only be necessary to prepare a 10 or 20 per cent solution, fill the specific gravity bottle or Sprengel tube (the "correction" for which had already been found), and weigh. Reference to a specially constructed table showing the dry substance content corresponding to a range of specific gravity values at various temperatures would give the "true" dry substance content immediately.

[W. R. M.]

Chlorosis of Sugar Cane.*

Results of investigations are recorded on what are known in Antigua as gall patches, which are unable to grow satisfactory crops of sugar cane, the crops planted on them usually assuming a characteristic chlorotic appearance, and frequently dying out after a time. These patches occur in the limestone districts of Antigua, but examination of the soil gave definite evidence that gall patches were not due, as has been suggested, to the presence of an excessive amount of calcium carbonate. The experiments showed that the chlorosis of plants, especially canes, on such patches was due to the presence of sodium in the soil, the origin of this sodium carbonate being attributable to interaction between the calcium carbonate and the sodium chloride dissolved in soil water, and brought up from saliniferous deposits at deeper levels. It has been found in Hawaii and Porto Rico that this condition is associated, in part at least, with a lack of iron in the plants. Dr. Tempany found that the only application producing a considerable increase in yield was stable manure mixed with ferrous sulfate; but that this increase was not sufficiently large to make the treatment profitable when the price of sugar is low. It is considered that the removal or amelioration of chlorosis can only be effected by a large scale system of irrigation, although it was possible that some improvement might be brought about by the application of calcium sulfate.

[W. P. A.]

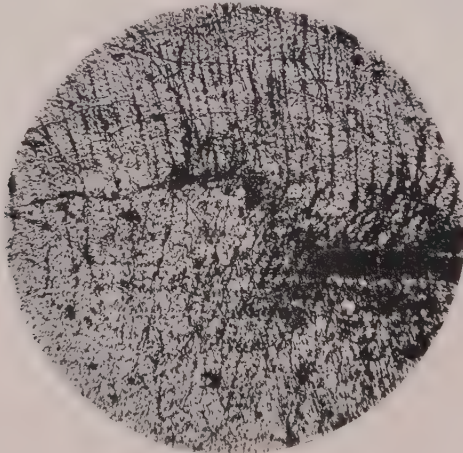
* Review of West Indian Bulletin, Vol. XVI, p. 137, by International Sugar Journal, July, 1919.

The Phenomena of Fatigue Failure.*

A fatigue failure of a metal, whether it occurs in a test specimen or in a machine part, is characterized by suddenness, lack of warning, apparent brittleness of material, and, in many cases, a fracture with a crystalline appearance over a part of its surface.

This crystalline appearance led to the old theory that under repeated stress metal "crystallized," changing from a ductile "fibrous" structure to a brittle "crystalline" one. This theory, however, has been quite thoroughly demolished as a result of study of the structure of steel under the microscope. As revealed by the microscope the structure of all metals used for structures and machines is crystalline, any "fibrous" structure being caused by inclusions of non-metallic impurities (for example, slag in wrought iron). Microscopic examination of metals under stress shows no change of the general scheme of internal structure, but under sufficiently heavy stress there appears gradual breakdown of the crystals in the structure.

When a ductile metal is deformed cold, the first deformation occurs in the particular grains which either take the most stress or have the lowest elastic limit. Deformation takes place by the slipping of one portion of the grain with reference to other portions. This slipping is shown by the appearance of lines called "slip bands" or "slip lines" extending across crystals and indicating planes of cleavage, as shown in the accompanying figure. As the load is increased, deformation proceeds and other slip bands are formed, the law being that the most easily deformable grains first show slip bands. Gradually the most favorable



Appearance of "slip bands," indicating planes of cleavage.

* From a progress report of the Committee on Fatigue Phenomena in Metals, acting under the joint auspices of the Engineering Foundation and the Division of Engineering of the National Research Council. (Mechanical Engineering, Sept., 1919, pp. 732-734.)

planes of slip are exhausted, and further slippage can take place only with the addition of more load.

The failure in ductile metals subjected to repeated stress takes place with substantially no general deformation. There is, however, considerable local deformation over microscopic areas, evidenced by the appearance of many slip bands on a polished surface of the metal after the application of repeated stress. These slip bands appear after a small number of reversals of stress with relatively large loads, and may not appear at all with slight loads. The slip bands may first appear either in the interior of a grain or at the grain boundary. As the number of applications of stress increases, more slip bands appear, and those first appearing usually lengthen and widen. Under the microscope and with normal illumination the general surface becomes blacker as the number and width of the slip bands increase. In ductile metals fatigue failure is almost exclusively through the grains themselves rather than at the grain boundaries, and the first slip bands to appear do not necessarily form a part of the final path of rupture. Failure seems to take place by the uniting of slip bands into cracks. When the first grain develops a crack extending across its entire width, added stress promotes the extension of this crack into adjacent grains on both sides, although the orientations of these grains may be and usually are such that the crack must extend itself at an angle to that in the initial grain. The general tendency is for these slip bands to follow the lines of cleavage of the particular grain in which they occur. Often incipient fracture is found in many grains adjacent to the final path of rupture, indicating that had rupture not taken place where it did, it would have soon taken place in some other adjacent part.

Such observations by means of the microscope indicate that *localized deformation* is the primary cause of fatigue failure in ductile metals, but it does not necessarily follow that the formation of one slip band under repeated stress will indicate eventual fracture if the loading is continued; one grain may appear to have a greatly reduced elastic limit because of internal strains or peculiarly unfavorable orientation. It is not certain that there is a limiting load below which fatigue failure will never take place.

Materials classified as brittle have very little permanent deformation under static stress, and under repeated stress the progressive fracture of brittle material might take place, not by slipping within crystals, but by tensile fracture of crystals. There has been practically no study made of the fracture of brittle materials under repeated stress, and it would be instructive to have tests carried out on brittle amorphous materials such as fused silica and on brittle crystalline materials like marble or tungsten. It is gradually being recognized that the breaking load of a specimen is a complex matter, and depends, among other things, on the time of application of the load. Mere duration of static loading, however, does not have an effect at all comparable with repetition of loading in reducing the breaking load. It seems evident that the distribution of stress in some brittle materials is very much less uniform than in ductile materials, and that fractures in brittle materials start on areas of high stress, whereas in ductile materials the high stresses are relieved by local yielding. A more complete understanding of the mechanism of rupture in brittle materials would doubtless be of great value.

When the action of metal under repeated stress is considered from the view-

point of the internal strains and accompanying stresses in the material, a radical difference is seen in the behavior of material under static load and under repeated load. In a general way we may consider any structural or machine part as subjected to static conditions if the load on it is applied gradually and is not repeated more than a few hundred times; the part may be considered as subjected to fatigue if the load on it is applied, say, one hundred thousand times or more; and for intermediate conditions of loading the phenomena characteristic of both kinds of loading would be present.

We must look upon steel as filled with a multitude of minute flaws. These flaws are developed in the solidification of the material. In static testing, steel under stress of about half its ultimate strength passes into a semi-plastic condition, in which there is a gradual flow of the material. Under such conditions the small flaws have almost no effect upon the flow or upon the static strength. When steel is loaded to moderate stresses the yielding is almost entirely elastic, but in general a small portion of it is inelastic, energy being taken up by the steel itself. If the specimen can be loaded a great number of times without heat loss its temperature will increase. If it is set vibrating in a chamber free from air it will stop vibrating in a short time, due to the absorption of energy. In such cases the stress-strain curve appears to be straight and the curve for the removal of the load may be practically identical with that for the application of load, but still these other effects show loss of energy in the steel itself.

This loss of energy is doubtless due to small displacements at these flaws, which are not reversible. Under alternate loading these displacements are made back and forth. Energy is continuously being absorbed in the location of these small flaws, and it is perfectly natural that they should increase in size. We must look upon these extensions of the flaws as occurring in a great many parts of the steel. If the stresses are small, the increase in size of these flaws is practically negligible, but if the stresses are larger, the increase is rapid, and later on in the history of the piece under test, very rapid, and finally the strength of the piece is terminated when a sufficient number of these flaws have connected so as to form an area of very great weakness.

For static loads all the above is of little consequence with a ductile metal; but it is of consequence in the case of a brittle metal like cast iron, which has a remarkably low strength in tension in comparison with its compressive strength. Ductile metals may be considered as having a very high value for cohesion with a rather low coefficient of friction—or whatever corresponds to that—so that these metals begin to slide on diagonal planes without actual fracture under high local stress.

When a ductile material is loaded it may be subjected to stresses whose average values for small areas are not very different for parts that are a tenth of an inch apart; but there is a multitude of tiny spots whose fiber stresses are 2, 3, 4 or 10 times the average value. This holds so long as elastic conditions obtain. As the applied stress increases, some of these stresses increase in like ratio, but not in like increments. At moderate applied stresses these special stresses reach inelastic conditions and slipping occurs. If the average stress is now entirely removed, we may assume that the unloading takes place in a similar manner. The small spots unload first in the elastic manner, but at a different

rate than the remainder of the material. They will unload approximately at the same rates as they used in taking stress, namely, 2, 3, 4 or 10 times the normal rate. For the unloading they have about twice the range of stress that they had in the loading before inelastic action is set up. Some of them will reach the opposite limit and slip part way back again, while some of them may not be subject to this return slip of inelastic action, but will retain in the unloaded state a stress distribution of the opposite kind. Either of these actions will give rise to hysteresis and to slight change of dimensions, usually, however, too small to be detected.

In all of the forging the main parts of the material have not been subjected to stresses which give inelastic action. If the loading is repeated without reversal, the spots that slipped on a first unloading will be subjected to further slipping both on loading and on unloading, but the areas that suffered no slipping on the first unloading should show no further inelastic action unless the loading is reversed. If the loading is reversed, however, all the particles that slipped in the first loading will slip on the reverse loading, so that with repetition a larger number of spots undergo this slipping action than is the case with loading which is not reversed. This explains the shorter life under reversed stress than under repeated stresses in one direction only.

If the fractured surface of a "rotating beam" specimen made of ductile metal and broken by repeated stress is examined, it is usually seen to be made up of two parts: (1) near the extreme fibers there is a dark surface with a dull, lusterless appearance, while (2) the remainder of the surface has a bright crystalline fracture. If these are examined more carefully it is found that their principal difference is in the size of the small flat surfaces that constitute the fracture. The center portion of the area has comparatively large surfaces, giving a crystalline effect, while the dull gray portion has very small surfaces of fracture.

An explanation of this is that the flaws in the outer portion of the surface have connected to form an annulus, whose rugged face is roughly at right angles to the axis of rotation. This has doubtless occurred slowly, and has started from many centers, thus giving the rough face. After this slow growth of flaws into an annular fracture has been accomplished the specimen has become very weak and the stresses have become so large at the fracture that they suddenly tear the metal in two on the natural surfaces of cleavage of the crystal grains.

The center portion of this fractured surface does not differ from the crystalline surface at the bottom of a cup in an ordinary static tension fracture, except that the crystalline surfaces are somewhat larger. This is to be explained by the fact that in an ordinary tensile test the material at the fracture has elongated something like 100 per cent, so that the crystal grains have become of smaller cross-section and will naturally show smaller facets on fracture, whereas, in a fracture of the endurance specimen, the material has had no chance to elongate and the crystalline grains have their normal size, which will be shown in fracture. It is not the crystalline portion of the broken specimen which has failed primarily by repeated stress, but the dull portion. In the crystalline part of the fatigue fracture and in the crystalline part of the static tension fracture the failure seems to be of the same nature, namely, a failure in cohesion.

In considering the phenomena of fatigue failure it may be well to call atten-

tion to the fact that there is an intermediate type of failure of ductile material in which both plastic action and the development and spread of microscopic flaws are present. Such failures sometimes occur in staybolts, boiler sheets between rivet holes, and other parts occasionally subjected to very severe local distortion.

[W. R. M.]

The Single Deflection Method of Weighing.*

By PAUL H. M. P. BRINTON.

Of the routine manipulations required in chemical analysis few are more important, and at the same time more tedious, than the operation of weighing, and any shortening of the time necessary for this would be a great help. Routine analysts usually find short cuts, but the research worker who carries through his analyses with a different end in view, and gives less thought to simplifying manipulative details, frequently wastes much time and patience in the use of the balance. The method described in this paper has been adopted after exhaustive tests as to its reliability and rapidity, and it seems only fair to offer to others the advantage of the great saving of time which this system effects, without the sacrifice of essential accuracy. The method was brought to the writer's attention a number of years ago by Dr. F. N. Guild, of the University of Arizona, who had used it for many years, but could not give the source from which it originally came. So far as can be learned, the procedure has never been described in book or journal, with the exception of a short paper by Turner.[†] It is believed that the method is almost unknown, and is used in very few laboratories. Those who have heard the method mentioned probably regard it with the same scepticism as did the writer, who refused to even try it for 10 years, so unorthodox did the system appear; and so little faith did he have that any degree of accuracy was obtainable by so simple a procedure.

The method is carried out as follows: The balance is given a permanent overload on the left arm by screwing the adjusting nut on one end of the beam until when the beam and pans are released the pointer will swing out from 3 to 7 scale divisions to the right. The pan arrests must be so adjusted that there is no lateral vibration of the pans when released. Before determining the zero point the stability of the pans is assured by moving the pan-arrest button in and out a few times. The beam is then freed, and the pans are next released by a gentle, steady motion. The pointer will swing out to the right, and the turning point of this single excursion is taken as the zero point. To obtain the weight of any object it is only necessary to add weights until the pointer is caused to swing out to the same point on the ivory scale. The convenience and rapidity of the method were immediately apparent, but grave doubts were entertained as to its

* Journal of the American Chemical Society, Vol. 41, p. 1151.

† Chemist-Analyst, January, 1916.

practicability and reliability until confidence was established by critical investigation.

CONSTANCY OF DEFLECTION.

A Becker aluminum balance was used, and four sets of weighings were made, each consisting of nine observations. The deflection readings are shown in Table I. The four sets were made in determining the sensibility of the balance with empty pans, and with 50 g. loads, so concordance between A and D, and between B and C, is not to be looked for. The arithmetical mean of each set has been calculated, and also the value of d/s , in which d represents the maximum deviation from the arithmetical mean in each set, and s the sensibility of the balance in scale divisions per milligram.

TABLE I.

										Mean.	d/s
A	3.7	3.75	3.8	3.75	3.8	3.8	3.75	3.8	3.75	3.77	0.015
B	8.8	8.8	8.8	8.85	8.75	8.8	8.75	8.85	8.8	8.80	0.010
C	8.65	8.7	8.6	8.6	8.6	8.65	8.65	8.65	8.6	8.63	0.015
D	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.6	3.55	3.60	0.010

It will be seen that with this balance the constancy of deflection fulfils the strictest demands of accuracy, for the values of d/s indicate that the greatest error of observation in this step will probably not exceed 0.015 mg. The weighings were made by an experienced manipulator, with a splendid balance, ideally situated, and with a reading lens for observation of deflections. To give the method a more thorough trial, experiments were made with a section of ten average students who had never handled an analytical balance (although three had had a course in assaying). These men were assigned to balances which cost from \$35 to \$75 each, selected at random in the regular student balance room. Each student made four sets of weighings, with five to seven observations in each set. The sensibilities of the balances registered from 2.6 to 4.9 scale divisions per milligram. In Table II are recorded the values of d/s , in which d was taken as the greatest deviation from the mean in any set for each student. The number of readings by each observer was from 20 to 28.

TABLE II.

Student ..	1	2	3	4	5	6	7	8	9	10
d/s	0.03	0.10	0.03	0.06	0.06	0.04	0.08	0.06	0.03	0.03

From this it is seen that in the work of entirely inexperienced students, with ordinary balances, any error introduced through inconstancy of deflection will probably not exceed 0.1 mg. These students had no idea that their results were to be tabulated for publication, and it is certain that further practice in weighing would increase the accuracy of their observations.

In order to test the effect of one's prejudice in favor of making all subsequent readings in any one set agree with the estimate made in the first observation, the same ten students were asked to read the deflection on one high-grade

balance. Only one student was allowed in the room at a time, so no mental prejudice was operative. The observations extended over a period of two hours, and the deflection was determined at intervals by the writer, whose readings are shown under the asterisks in Table III. Each student made five to seven observations, and in the case of only one operator did a deviation from the mean as great as 0.1 scale division occur. The sensibility of the balance was 5.0.

TABLE III.

Student	*	1	2	3	4	*	5	6	7	8	9	10	*
Deflection	3.7	3.7	3.8	3.7	3.8	3.8	3.8	3.8	3.8	3.8	3.9	3.8	3.85

From the writer's observations it seems probable that the zero point shifted a tenth of a division or so during the period, and taking this into account one must be struck by the concordance of the readings of 11 experimenters, 10 of whom were inexperienced.

For those trying the method on a very sensitive balance it is suggested that attention be paid to the effect of the current of air, or the lengthening of the beam, caused by the heat of the hand near one pan, for it will be found that the first swing does not always accord with those which follow. This method is so rapid that irregularities are easily detected which would frequently escape observation by ordinary manipulation.

The balance case had been closed a long time, and these deflection readings were taken:

3.9 3.9 3.9 3.9 3.9 3.9

The hand was then held 15 seconds near the left pan, and as soon as the door had been closed, the following series of observations was begun:

4.0 3.95 3.9 3.9 3.9

The experiment was repeated, holding the hand near the right pan for 15 seconds, with the following results:

3.6 3.9 3.95 3.9 3.95

It is seen that with a sensitive balance a few moments must be allowed for abatement of jar and air currents, but equilibrium is soon re-established. This is not to be construed as a criticism peculiar to this particular method, for it will be understood that the same precaution is necessary with any system of weighing.

BEHAVIOR WITH VARIOUS LOADS.

Two faults frequently found in balances, especially in those of cheaper grade, are varying sensibility under increasing load, and inequality in the lengths of the two lever arms. It is evident that both these conditions would influence the accuracy of absolute weighings by the single deflection method, but in nearly every instance in analytical work the weighing consists in comparing the weight of an empty vessel (watch glass, crucible, or dish) with that of the same vessel containing at most a few grams of sample or ignited precipitate. Manifestly, then, the error introduced by varying sensibilities, or by inequality of arms, would be negligible in nearly all cases of analytical practice. The method has been suc-

cessfully used by students in calibrating weights by the method of Richards,* and a few hours only are required by even a beginner for the calibration of a full set of weights.

PRECAUTIONS AND LIMITATIONS.

The single deflection method of weighing cannot be used with those types of balances in which the beam and pan-arrests are all released by one operation, as by the turning of one milled head or lever; and it has occasionally been found that a balance of the correct general type has failed to give concordant readings in successive weighings. In nearly every instance it has been found that these balances failed to yield concordant weighings by any other method.

The pan-arrests must be clean and adjusted to the proper height. A little alcohol will remove any grease which might tend to cause sticking of the pan-arrest to the bottom of the pan.

A little experience with a particular balance will soon show one just how far the method can be trusted with that instrument. With the balance habitually used by the writer, which has an unvarying sensibility with loads up to 50 g., the method is regarded as suitable to work of the very highest accuracy. It is realized that the error of a single observation should be greater than that of the mean of three or five observations, but it may be pointed out that it is much easier to read with the highest accuracy when the swing is to one side only, and does not cross a center point. Furthermore, the chance for lapse of mental concentration and attention is greatly diminished in the single deflection method. In work of great importance the weighing can be checked by a second weighing in less time than is needed for one weighing by the conventional methods.

It is certainly not advisable to teach this method to students as their sole equipment for weighing operations, for a number of good balances on the market are of the "single release" type; but with proper emphasis on the limitations of the process the single deflection method can be given to students with great benefit. An analyst who will weigh out a 3-g. sample of steel, for determination of phosphorus, with an accuracy greater than within 1 mg., has little greater chance of success in the world than he who will weigh out a 0.2-g. sample of copper foil, for standardizing, with an accuracy less than within 1 mg.

[W. R. M.]

* The Journal of the American Chemical Society, 22, 144 (1900).
